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# THE RELATION OF PLUMAGE TO OVARIAN CONDITION IN A BARRED PLYMOUTH ROCK PULLET.<sup>1</sup>

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The assumption by female birds of plumage and other external characters which ordinarily distinguish the male is not an uncommon phenomenon and has long been noted. While it is known to occur among wild birds (Hunter, 1780, p. 532), it has been much more commonly observed in domesticated varieties or others retained in captivity, where the opportunity for close observation is obviously much greater. An excellent general summary of the literature on the subject, including a most useful bibliography, has recently been published by Larcher (1916).

Cases have most frequently been reported in fowls, pheasants and ducks, and it is probable that most poultrymen of wide experience have known of their occurrence. A careful search of the poultry journals would doubtless reveal mention of many cases, though the proportion which gets into print must be relatively small, and the number that receive scientific attention even smaller. One such has been reported recently (Dent, 1917) of a mongrel Barred Plymouth Rock which was claimed not only to have laid eggs but also to have treaded hens. It was stated, furthermore, that the eggs from these hens with which the hermaphrodite mated were successfully hatched. The bird in question was also said to crow at times and to sing like a hen every day. A photograph accompanying the letter shows a bird with a head like a cock, but body more resembling a hen. If confirmed, this would be an extreme case of hermaphroditism.

<sup>1</sup> Contribution from the Department of Genetics, Agricultural Experiment Station, University of Wisconsin, No. 14, and from the Kansas Agricultural Experiment Station. Published with the approval of the Directors.

An extensive study of a number of similar, though less extreme cases, has just appeared (Boring and Pearl, 1918), and these will be mentioned later in connection with our own case.

In the foregoing cases the non-functioning of the ovary and the consequent deficiency of ovarian secretion was due to natural causes, probably in most instances to a diseased condition of the ovary. The deficiency of ovarian secretion can also be brought about by artificial removal of the ovary. This is a delicate operation but has been successfully accomplished and the effects on ovariectomized birds have been reported by Guthrie (1910) on a hen, Fitzsimons (1912) on ostriches, and Goodale (1913, 1916*a*, 1916*b*) on chickens and ducks. In all cases more or less complete assumption of characteristic male plumage, and in varying degrees of other masculine characters, appeared after the ovaries were removed, some individuals, as Goodale says, becoming "nearly complete replicas of the male."

The subject of the present note was a purebred Barred Plymouth Rock pullet. She was hatched on the poultry farm of the Kansas State Agricultural College in 1915 and received the number 1050, as a consequence of which she has since been designated in our records as "Kansas 1050." In the early months of her life she was not noticeably different from her sisters and flock mates, and it therefore happens that no photograph was taken of her during that time. In February, 1916, she was put into a breeding pen as a normal pullet, along with others, but some time later it was noticed that she was taking on marked male characteristics, particularly with respect to plumage. Fig. 1 shows her appearance in April, 1916, while Fig. 2 is one of her normal flock sisters at about the same time. For purposes of comparison a photograph (Fig. 3) is also introduced of a normal cockerel, a full brother of the pullet shown in Fig. 2. A comparison of these photographs shows even better than words can describe the character relations of the three individuals. It will be seen that "Kansas 1050" has almost perfect male plumage, except that the sickle feathers of the tail are not so long and the breast and under parts are slightly darker, due to the fact that the white bars on the feathers are somewhat narrower in proportion to the black. The characteristic difference

in barring in males and females of the same strain is illustrated in Figs. 2 and 3. This will be discussed later.

The change in plumage between February and April denotes of course, that a molt occurred during this period. As the normal season for molting is in the fall, this is in itself a matter of interest and implies some underlying physiological process. In view of the close relation well known to exist between molting and ovarian activities, it seems reasonable to suppose that the bringing on of the molt at an unusual season, as well as the modification of the character of the new plumage, was due to changes in the ovary induced by the development of the pathological condition to be described later. While the effect on the character of the plumage is very likely the direct result of the action of changed internal secretions from the sex gland, it seems more probable that the molt is a secondary effect due to the change in metabolism, since in general molting seems to be most closely linked to metabolic conditions of the individual. This is indicated by the fact that molting may at times be induced by other conditions than changed sex-gland activity, such as change of feed, injury, and other environmental influences.

In other respects "Kansas 1050" was at that time rather intermediate between the normal pullet and cockerel. The head and comb were more like that of the pullet; shape and carriage of the body were intermediate. Spurs were not developed. In general she may be said to have looked much like a capon, a resemblance which was noted by a number of observers.

"Kansas 1050" was brought to Madison in the fall of 1916 and was merely kept under observation all of that winter. Her behavior during that time showed nothing of special interest, and in so far as indications of sexuality were concerned was practically indifferent. She seemed in excellent health and "sang" a great deal, somewhat resembling a hen in this respect, except that the voice had a peculiar more or less masculine quality. She was never heard to crow. She showed no indications of laying, and it was suspected that she probably had an ovarian tumor, which would account also for the plumage change. Thinking that possibly the accessory sexual organs might be

normal even though the ovary was affected, we decided to try the experiment of removing the tumor and of ingrafting an ovary from another individual, in order to see what effect it would have on the secondary sexual characters, and also in the hope that eggs might be produced normally from the engrafted ovary.

The operation was undertaken on April 8, 1917, an incision being made in the usual place for caponizing. This disclosed an enormous tumor, estimated to be some 10 cm. in diameter, and highly vascular on the surface. It seemed probable that the tumor was of ovarian origin, but on account of its size its point of attachment could not be definitely determined. Its removal was, moreover, deemed impracticable because of the highly developed and ramifying vascularization. Consequently several pieces of ovary from a freshly killed "white" Andalusian pullet were inserted loosely into the body cavity, and the wound closed. This pullet was nearly ready to lay, an ovum having already entered the oviduct; but only pieces of the ovary with very small ova were used for transplantation.

The patient made an uneventful recovery, except that the ether used as the anæsthetic apparently caused some irritation of the air passages, resulting in a slight "rattling" in the breathing, which persisted for some time. General health, however, appeared excellent, and the bird was bright and active.

On May 3 a white Wyandotte cock was put into the pen with "Kansas 1050" to test their behavior. He showed no antagonism to "Kansas 1050" but treated her as if she were a female, in spite of her male appearance. She on her part behaved more like a female, showing no fear of the cock and coming at his food call. She did not, however, display any signs of sexual activity.

On this date new feathers were beginning to come in on the area which had been plucked for the operation, and as they seemed to differ somewhat in character from the old feathers, other areas were denuded in order to make a further test of the matter. For this purpose the hackle, saddle and sickle feathers were plucked from the left side of the body, leaving those on the right side in place. By July 28, when the photographs reproduced in Figs. 4 and 5 were taken, the feathers on the neck and

lower back had been entirely replaced, but new tail feathers had not yet grown out. Fig. 4 shows distinctly the difference in the old feathers on the right side of the neck and the new feathers on the left side. The difference is even more marked on the lower back, as shown in Fig. 5. In both locations the new feathers on the left appear darker and are distinctly hen-feathers in shape while the older feathers of the right side are lighter and elongated like those of a cock. A careful comparison of the two sets of feathers was made to ascertain how closely they resembled normal feathers of the two sexes respectively.

The American Standard of Perfection<sup>1</sup> stipulates that in the ideal of the Barred Plymouth Rock breed, "the light and dark bars [are] to be of equal width, in number proportionate to length of feathers, and to extend throughout the length of feathers in all sections of the fowl." Every breeder who has had any experience with this breed of fowls knows that this standard is a purely artificial one, for in any particular strain the males always run lighter in color than the females (compare Figs. 2 and 3) there being, as Pearl and Surface (1910, p. 47) remark, "actually a sexual dimorphism in respect to plumage color in Barred Plymouth Rocks as they are ordinarily bred." This has driven the fancier to a system of breeding commonly known as "double mating," but which really means the carrying along side-by-side of what are virtually two sub-varieties of the breed, one in which the pullets are very dark and the cockerels approach the Standard requirements, and the other in which the pullets are about medium and the cockerels much lighter. For showing in the Standard classes males are chosen from the former line and females to match them from the latter. The dark "cockerel bred" pullets and the light "pullet bred" cockerels are sometimes shown in entirely distinct classes as breeding stock. The males and females of Standard color are not bred together, but each is mated to selected birds of its own breeding.

This fact was commented on a number of years ago by Spillman (1909), who suggested it would be wiser for the fancier to endeavor to learn just the shade of difference which "nature tries to produce between the sexes and then change the Standard

<sup>1</sup> Amer. Poultry Assn., 1915, p. 50.

accordingly." His explanation of the natural difference in shade in the two sexes is that the males are homozygous whereas the females are heterozygous with respect to barring. "The males, therefore, have twice as much tendency to barring as do the females. The males are therefore more barred than the females and hence are lighter in color." By "more barred" Spillman means that the white bars are wider in proportion to the black. This difference in the relative widths of the white and black bands on the feathers may be noted in the normal cockerel and pullet, Figs. 2 and 3, but is more evident in the individual feathers shown in Figs. 7-10. These feathers, while not from the same individuals shown in Figs. 2 and 3, are from birds of the same breeding as these and "Kansas 1050." Fig. 7 is a neck feather from hen 804, which was a flock sister of "Kansas 1050," while Fig. 8 is a feather from the cushion, or lower back, of the same bird. Fig. 9 represents a hackle feather, as it is called in the male, from the neck of a cock bird, 104E, which is the son of a flock sister of "Kansas 1050." Fig. 10 is a saddle feather from the same male, being from the position corresponding to the cushion in the hen. It will be noticed that in addition to the differences in shape in the two sexes, the white and black bars on the hen's feathers are of practically the same width, while on those of the cock the white bars average considerably wider.

From the photograph of the neck feathers of "Kansas 1050" in Fig. 4 the impression is gained that the masculine feathers of the right side have broader white bars; but that such is not the case on the lower back is evident from a careful inspection of Fig. 5. Furthermore, the fact that the white bars are of the same width in the old and new feathers of both these regions is convincingly shown in Figs. 11-14. Figs. 11 and 12 are neck and lower back feathers respectively from the left or "feminine" side, while Figs. 13 and 14 are corresponding feathers from the right or "masculine" side. The lighter appearance of the "cock" feathers of the right side is therefore not due in this case to relatively wider white bars, but must be attributed to the fact that they are older and consequently the black has faded to some extent, and to the difference in form and structure. Normal cock feathers are more elongate in these regions, and they differ

in structure from the hen feathers in that the firm web is relatively as well as absolutely narrower. In the feathers of the female the barbules interlock practically to the edge of the feather, making nearly the whole surface into a fairly firm web, but in the male the hackle and saddle feathers have a firm web only in the middle portion, practically the outer half<sup>2</sup> of the barbs being free of barbules and presenting a frayed appearance. These free barbs, together with the longer, pointed loose ends of the feathers cause the relatively rough, stringy texture of the hackle of the cock as compared with the smooth neck of the hen. The loose structure of the feathers in the former case, causing greater diffraction of the light, undoubtedly contributes to a lighter appearance of the hackle, irrespective of the broader white bars under normal conditions. Thus it will be noted that in "Kansas 1050," the masculine feathers assumed presumably as a result of the diseased ovarian condition were like cock feathers in respect to shape and structure, but still resembled hen feathers in the matter of width of bars, as shown by comparison with the new hen feathers grown after the new ovarian tissue was introduced.

The above would appear to support Spillman's interpretation of the normally wider white bars in the male as being due to homozygosis for the factor for barring. The form and structure of the feathers would thus be considered as secondary sexual characters dependent on the functioning of the sex gland; barring, however, being dependent directly on the genetic factor, would remain the same, whatever the sexual hormones. Although the failure of the ovary to function properly gave rise to a condition of internal secretion which led to the assumption

<sup>2</sup> Goodale's statement (1918, p. 292) that "the secretion of the ovary is necessary for the development of the barbules of the feathers of the dorsal regions since the barbules do not develop along the entire length of the barb in the male or in the capon" seems to be at variance with the above. If he means, as he seems to say in substance, that there are no barbules in the hackle, back, or saddle feathers of the male, his observations are certainly different from ours on Barred Plymouth Rocks. It is true that at the tip of the hackle feathers there are no barbules, but farther down they are to be found at the bases of the barbs, while just above where the fluff begins they run out practically to the extremities of the barbs. The statement that they are free on "the outer half" represents the average condition, or that found about midway from the fluff to the tip of the feather.



of male plumage with respect to shape and structure of feathers, the soma was still heterozygous for the barring factor and consequently the white bars in the "cock" feathers remained narrow as in the normal female. Davenport (1912, p. 17) classified sex-dimorphic characters into two classes: "(a) characters whose development is controlled primarily by determiners located in the sex-chromosomes and, (b) characters whose development is specially influenced or modified, probably by secretions of the sex-glands." In "Kansas 1050" we have both these classes represented in the same feather.

In the hackle and saddle feathers of the male the bars are less straight and regular than in the corresponding feathers of the female or in other parts of the plumage of either sex. In general there is a lagging of the middle portion of the bar, at the shaft, producing a more or less V-shaped bar instead of one straight across. This is illustrated in Figs. 9 and 10, and Figs. 13 and 14 show that the corresponding feathers on "Kansas 1050" had the same character. Thus it would seem that *shape* of bar, unlike *width*, is a secondary sexual character rather than sex-linked.

But while our case conforms to the interpretation given above, Pearl and Surface (1910, p. 53) state that in the cross between Barred Plymouth Rock and Cornish Indian Game "there is the same sort of sexual dimorphism in color pattern to be observed in the hybrids as in the pure Barred Plymouth Rocks," and specifically that "the male hybrids have narrower dark bars on the feathers especially in hackle and saddle feathers than do the females." These cross-bred males must of course have been heterozygous for barring, so that on Spillman's hypothesis they should have had the same width of bars as the hens. The fact that the crossbred males were darker than pure Barred Rock males does not alter this point, so that the matter cannot be considered as settled. It is of course possible that there were genetic factors carried by the non-barred breed (Cornish Indian Game) which might have had some modifying effect on the barring of the crossbred offspring.

"Kansas 1050" was killed and autopsied on July 28, 1917. Her behavior subsequent to the operation had not been notice-

ably different, but it was noted that for two or three weeks prior to the above date she had often been observed forenoons sitting in a nest-like depression in the straw. The notes also state that she had been a consistent "singer," keeping up a little crooning note a good share of the time.

The autopsy revealed the visceral organs normal except for an enormous tumor (Fig. 6) which filled practically all of the left side of the abdominal cavity and caused a marked abdominal protrusion. The tumor was for the most part highly vascular on the outside; it was roughly knobby, the larger knobs being several centimeters in diameter and dark purplish, almost black, in color; most of the smaller ones somewhat more reddish. The freshly removed tumor weighed 289 grams. The bird was not weighed before killed, but after the tumor was removed, most of the blood washed out and nearly all the feathers off, the carcass weighed 2,350 grams.

The tumor was attached at the normal site of the ovary, though the mesenteries were somewhat adherent to it at other points. There appeared to be no normal ovarian tissue remaining, nor, for that matter, was any trace found of the implanted pieces of ovary—at any rate anything which was positively identified as such.

The interior of the large knobs of the tumor exhibited a coarse trabecular structure, the trabeculae being very dark and the matrix of a yellowish brown color. The smaller, softer knobs contained considerable blood, while the others were firm and hard. Greatest length of tumor, measured fresh, 13 cm.; breadth, 9.5 cm.

The oviduct had the appearance of that in a normal non-laying pullet.

The tumor was preserved and later referred for examination to Dr. C. H. Bunting, of the Department of Pathology at the University of Wisconsin. He has kindly given us the following description based on his study of the specimen. It seems advisable to publish this in full as a contribution to the knowledge of the anatomy of ovarian tumors in fowls.

"The specimen consists of a somewhat cruciform laked mass approximately  $12.5 \times 8.5 \times 7.5$  cm. in size. A distal small lake

approximately 2.5 cm. in diameter appears to be a subcapsular hæmorrhage. A large central lake appears to be made up almost entirely of large vascular channels and to be the site of extensive hæmorrhage. The proximal lakes show numerous large vascular channels separated by tissue, in the main rather translucent and glistening, but showing numerous small opaque areas.

*“Microscopical Study.*—Sections from the larger lake show many large channels filled with blood. Some of the larger of these are thrombosed; some of the thrombi are comparatively recent, others are old and show deposits of calcium salts in the hyaline material. The intervening tissue, which is small in amount, is necrotic.

“Sections from the proximal lakes show numerous vascular channels, few of which are thrombosed. These channels are separated by a considerable amount of connective tissue, which is in most places cellular, and apparently of recent growth. This tissue is in many places thickly infiltrated with lymphocytes and with numerous cells with eosinophilic granulation. There are recent small hæmorrhages into the interstitial tissue and evidence of old hæmorrhages, in the presence of hæmosiderin masses.

“In addition to the changes described there are throughout the intervascular tissue in these sections alveoli of various sizes, but usually small, solidly filled with cells of an epithelial (or endothelial) appearance. The cells vary much in size and appearance. The average cell has a nucleus of from  $12\ \mu$  to  $15\ \mu$  in diameter with distinct nucleolus and fairly heavy chromatin network. The protoplasm is abundant, granular, and shows a tendency to fatty degeneration. The cell outline varies. In some alveoli they are almost columnar, in others spindle-shaped, and in others their outline is difficult to determine as the cells are closely united into sheets or columns resembling a syncytium. While most of the vascular channels are lined by a delicate flattened endothelium, in some places they have a lining of high irregular cells of the character seen in the intervening alveoli. One further gains the impression that it is from such layers that the cells of the alveoli are derived. No evidence of ovarian structure is found in the sections.

"*Diagnosis*.—Vascular malignant tumor, apparently of endothelial origin."

The case of "Kansas 1050" falls naturally into the series described by Boring and Pearl (1918). The assumption of male plumage was obviously due to the degenerate and pathological condition of the ovary, and admits of the same interpretation that they give, namely that the general correspondence of the secondary sex characters to the primary sex organs "might be accounted for in accordance with the theory that the ovary forms an external secretion that inhibits maleness." No indication of a testis nor of testicular tissue was found in "Kansas 1050," though the search for it was not perhaps as careful as it might have been. The principal interest of our case seems to lie in the enormous size of the tumor, associated with apparent good health, the immediate effect on the incoming feathers of implanted ovarian tissue and the relations of form, structure and barring of the two sets of feathers.

#### SUMMARY.

1. A purebred Barred Plymouth Rock pullet, designated as "Kansas 1050," which at first appeared normal, later assumed plumage much more resembling that of a normal male, and became much like a capon in general appearance.

2. This change in secondary sexual characters was obviously due to the development of a very large ovarian tumor.

3. Implantation of ovarian tissue from a normal pullet produced an immediate effect on new plumage assumed. New feathers grown in the few weeks succeeding the operation were definitely hen feathers.

4. The "male" feathers assumed early in life as a result of the pathological condition of the ovary, though like normal male feathers in shape and structure, resembled hen feathers in respect to barring. This distinguishes clearly the difference between *secondary sexual dimorphism*, as exhibited in the first instance, and *dimorphism caused through sex linkage*, as illustrated by the barring.

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NOTE.—While the foregoing paper was in press there came to our attention a paper by Albert Pézard on "Le conditionnement physiologique des caractères sexuels secondaires chez les Oiseaux. Du rôle endocrine des glandes génitales," Bull. Biol. de la France et de la Belgique, T. 52, Fasc. 1 et 2, pp. 1-176. This is a very interesting contribution to the literature of the genital glands in birds as endocrine organs and has an extensive bibliography, mostly of foreign references.

## EXPLANATION OF PLATE I.

FIG. 1. Barred Plymouth Rock pullet "Kansas 1050" after assumption of male plumage.

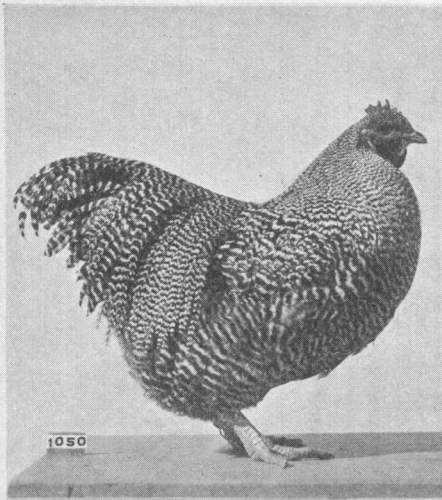
FIG. 2. Normal Barred Plymouth Rock pullet (Kansas Station No. 890), a flock sister of "Kansas 1050," and of approximately the same age.

FIG. 3. Normal Barred Plymouth Rock cockerel (Kansas Station No. 21M), a full blood brother of pullet 890.

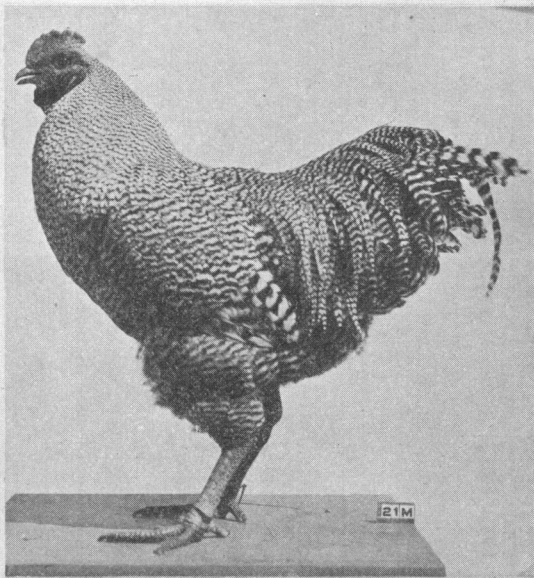
FIG. 4. Plumage on back of neck of "Kansas 1050," photographed on July 28, 1917, nearly four months after implantation of ovarian tissue. The difference between the old "cock" feathers on the right side and the new "hen" feathers on the left side is plainly distinguishable.

FIG. 5. Dorsal view of "Kansas 1050," taken on July 28, 1917, showing the old and new plumage, particularly on the lower back.

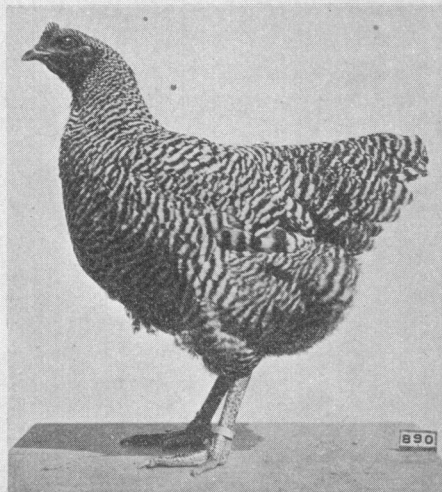
FIG. 6. Ovarian tumor from "Kansas 1050."



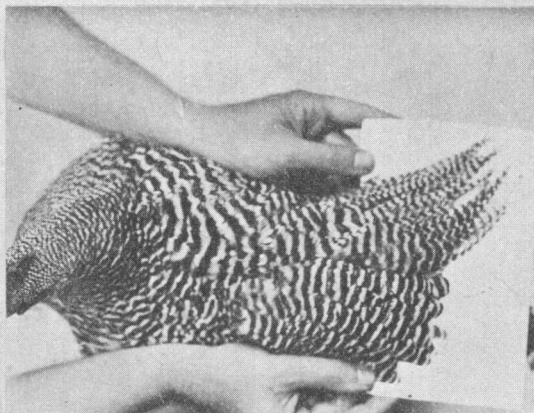
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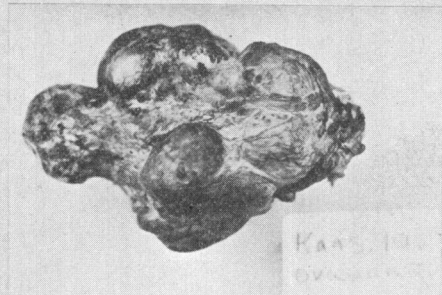
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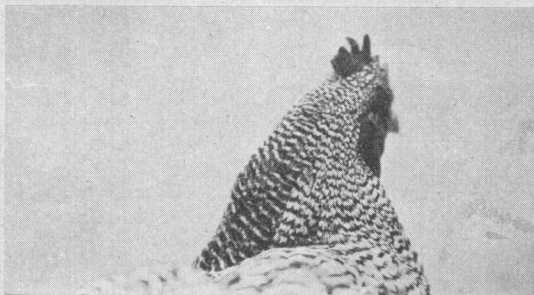
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6



4

## EXPLANATION OF PLATE II.

*Barred Plymouth Rock Feathers.*

FIG. 7. Neck feather from normal female (Kansas Station No. 804).

FIG. 8. Cushion feather from normal female (Kansas Station, No. 804).

FIG. 9. Hackle feather from normal male (Kansas Station No. 104E).

FIG. 10. Saddle feather from normal male (Kansas Station No. 104E).

FIG. 11. Neck feather from left ("hen feathered") side of "Kansas 1050," July 28, 1917.

FIG. 12. Cushion feather from left ("hen feathered") side of "Kansas 1050," July 28, 1917.

FIG. 13. Neck (hackle) feather from right ("cock feathered") side of "Kansas 1050," July 28, 1917.

FIG. 14. Saddle feather (from position corresponding to cushion) from right ("cock feathered") side of "Kansas 1050," July 28, 1917.



